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Subject: Bark Beetle Activity on the Alpine RD

To: District Ranger, Alpine RD, Apache-Sitgreaves NFs

Monica Boehning, Silviculturist with the Alpine RD, requested that an entomologist with the Arizona Zone Forest Health Protection (FHP) office assess the Alpine area for bark beetle activity. On August 14-16, 2002, I traveled to the Alpine area and developed recreation sites on the Alpine RD. On August 14th, I met with Alpine RD personnel to discuss bark beetle issues on the District, in particular, surrounding the town of Alpine. These discussions occurred at the District office, north of town in an area slated for fuel reduction treatments, and at areas thinned from between 6 years to 6 months ago.

On the 15th and 16th, FHP seasonal employees Brian Howell and Steve McKelvey and I assessed bark beetle activity in Alpine vicinity and developed recreation sites on the Alpine RD. I describe in this report what bark beetle activity was observed in these areas, describe bark beetle biology and potential impacts, summarize prevention and control alternatives, and make recommendations to minimize bark beetle impacts. Prior to our visit to Alpine, Monica provided us a list of questions pertaining to bark beetle management for the Alpine area. I will address these questions within this report.

Bark beetle activity adjacent to Alpine

Both aerial detection surveys and ground surveys conducted by FHP, found high levels of bark beetle-killed ponderosa pine in the Alpine area (*Figure 1*). Inspection of fading trees determined that pine engraver beetles (*Ips pini* and probably other species) are the primary cause of pine mortality. Most of these attacked trees showed the characteristic fading from the top down (*Figure 2*). Many of the larger diameter pine with top kill also have western pine beetle (*Dendroctonus brevicomis*) beginning to attack the lower portion of the trunks. No roundheaded pine beetle (*D. adjunctus*) was observed within the Alpine area.



FIGURE 1. PINE ENGRAVER BEETLE ACTIVITY IN THE ALPINE AREA.



The highest levels of pine mortality were observed on south-facing slopes on the north side of town and both sides of Highway 180 east of town. Less tree mortality was observed on the west side of town.

A summary of the aerial detection survey results will be provided to the District at a later date; however, a preliminary color copy of the sketch maps for the Alpine RD was given to Monica Boehning on August 15th. This pine mortality is not unique to the Alpine RD. High levels of both ponderosa and pinyon pine mortality have been documented across the state and throughout the Southwest during 2002. Within many of these areas, ponderosa pine mortality is already greater than 25% for a given stand and is as high as 90% in others. The vast majority of this pine mortality is related to the ongoing drought that the Southwestern Region has been experiencing since 1996. If beetle populations continue to increase at the rate they have over the past few years, we can expect to see even greater levels of mortality throughout much of the Forest.



FIGURE 2. TOP KILL OF PINE BY IPS IN THE ALPINE AREA.

Bark beetle activity near Alpine

FHP personnel also visited National Forest System lands adjacent to private property along Jackson Creek (FR 281/571), Pace Creek (FR 8153), FR 275, and lands surrounding the burn pit on FR 281. A 6-acre area was surveyed adjacent to private property at the junction of FR 281 and 571. An average of 5 infested trees per acre was found in this area. Higher levels of tree mortality were observed on some of the south-facing slopes. Similar levels of tree mortality were seen on National Forest System lands adjacent private property near Pace Creek (FR8153).

Although a formal ground survey was not conducted at Pace Creek, a roadside survey showed pine mortality within this area, particularly on the east side of the private property.

Higher levels of pine mortality were recorded near the Burn Pit on FR 281. A 2-chain-wide ground survey around the circumference of the Burn Pit found more than 200 ponderosa pine (25+/acre) attacked by pine engraver beetles (*Figure 3*). Most of the mortality was concentrated within clumps of 10 to 60 trees. A wide variety of tree sizes were attacked



FIGURE 3. PINE ENGRAVER BEETLE-KILLED PINE ADJACENT TO BURN PIT SOUTHEAST OF ALPINE.

within these areas, ranging from 3 inches DBH to greater than 25 inches (9.2 inches average). Similar to the Alpine area, essentially all of the trees were attacked by pine engraver beetles with a lesser number having western pine beetles in the lower portion of the trunks.

Bark beetle activity in developed recreation sites

Trees growing in developed recreation sites are often stressed due to repeated damage caused by campers and soil compaction caused by roads and large vehicles parked off-road. During periods of drought or below-average precipitation, such as has been occurring over the last few years, these trees can become extremely stressed. This is further exacerbated by the relatively high density of ponderosa pine growing in and adjacent to some of the campgrounds. When trees are growing at high densities, there is more inter-tree competition for limited resources, such as light, water, and nutrients (Kolb et al., 1998). The combined effect of these factors is to lower production of defensive compounds by the trees and, consequently, increase susceptibility to bark beetle attack. Bark beetles may also prefer these dense stands, as compared with more open stands, due to microclimate differences (Amman and Logan, 1998).

Several of the developed recreation sites were surveyed for bark beetle activity. Specifically, we looked at Luna Lake CG and Alpine Divide CG near Alpine and a series of campgrounds along the East and West Forks of the Black River (*Table 1*). Approximately 40 ponderosa pines were attacked within or adjacent to Luna Lake CG. Only one ponderosa pine was attacked at the Alpine Divide CG. Campgrounds along the East Fork of the Black River had relatively low levels of bark beetle activity (*Table 1*), except for the Horse Springs CG/Porcupine Picnic area in which there are many currently infested small-diameter pine. This developed recreation site has a high density of smaller-diameter ponderosa pine. The campgrounds higher in elevation had a combination of roundheaded pine beetle and Douglas-fir beetle activity (*Figure 4*), while lower elevation campgrounds had primarily pine engraver beetle activity.

Table 1. Summary of bark beetle activity in recreation sites on Alpine Ranger District.

Recreation site	Bark beetle-killed pine	Bark beetle-killed Douglas-fir
Luna Lake CG ¹	>40	0
Alpine Divide CG	1	0
Diamond Rock CG	2	2
Aspen CG	0	3
Deer Creek CG	0	1
Horse Springs/Porcupine CG ²	12	0
West Fork Black River CG ³	0	0

¹ Pine mortality at Luna Lake was estimated by a roadside survey.

² Horse Springs CG also had approximately 15 pines that were killed by beetles more than 1 year ago and were near campsites. These dead pines should be considered hazard trees.

³ Three pines adjacent to campground host had red turpentine beetles attacks.



FIGURE 4. ROUNDHEADED PINE BEETLE GALLERIES (LEFT) AND DOUGLAS-FIR BEETLE GALLERY WITH EGGS AND PITCH TUBE (CENTER & RIGHT) IN DIAMOND ROCK CG.

Bark beetle biology

A brief description of bark beetle biology is provided so that alternatives for prevention and suppression may be better understood.

Pine engraver beetles. Adult pine engraver beetles attack smaller diameter trees and tops of larger trees, but their preferred host material is fresh pine debris from construction (*Figure 5*), logging, firewood cutting, or blowdown. Living trees can be attacked and killed once populations have built up in fresh pine debris. Several generations are produced per year. Adults emerge from overwintering material and fly to find new hosts in the spring (i.e., early April). Pine engraver beetles flights continue into the fall as long as daytime temperatures remain above 60° to 65° F. Generation time from egg to mature adult beetle ranges from one month to 8 weeks, with the shortest development time in mid-summer. Males initiate attacks and release chemicals, which attract females. Adults build galleries (or tunnels), mate, and lay eggs. Galleries are distinctive. Typically there is a central nuptial chamber (an enlarged area) from which several more or less linear adult galleries radiate.

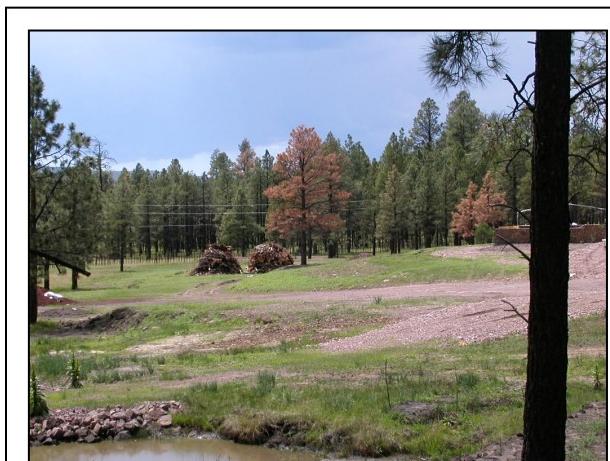


FIGURE 5. IPS ACTIVITY ADJACENT TO CONSTRUCTION AND SLASH PILES.

Galleries slightly etch the sapwood, hence the common name, engraver beetle. Frequently three galleries originate from the nuptial chamber in the shape of a tuning fork. Adult galleries are open and not packed with boring dust. Larvae (immature beetles) feed in their own galleries perpendicular to the adult galleries for a few weeks before pupating. Pupae turn into adults to complete the cycle. Evidence of attack includes fading foliage, red boring dust in bark crevices and occasionally small pitch tubes on trunks of live trees. Because attacks are typically initiated near the tops of trees, the crown fades from the top down (*Figure 2*).

Western pine beetle. The western pine beetle attacks trees of all sizes larger than 6 inches in diameter. However, large, old trees are attacked most commonly. Unlike the pine engraver beetles, this insect attacks living trees and rarely is found on pine debris. Best evidence of attack is the presence of pitch tubes (up to 1 inch in diameter) in the bark, often in bark crevices. Under the bark, galleries are mazelike and do not etch the wood (contrast with pine engraver beetles). Life cycle is quite similar to engraver beetles. All life stages are found in bark. Between two and four generations are produced per year. Flight and attacks start in late spring or early summer and continue until the onset of cold weather in fall. Attacks are initiated by adult females, usually at mid to lower trunk. The infestation process is mediated by chemical messengers or pheromones released by the beetles in combination with host tree chemicals. Adults construct egg galleries. They differ from pine engraver beetles galleries in their shape and by the fact that they are packed with boring dust. Larvae feed in their own galleries perpendicular to the adult galleries. Later larval stages tunnel in the middle bark before pupating and eventually emerging. One generation requires between 2 and 10 months depending on temperature.

Effects of bark beetle infestations in ponderosa pine stands of Arizona

The amount of tree killing varies considerably during bark beetle infestations. Sometimes only a few groups of trees are attacked and killed, but in other situations literally thousands of pine trees can be killed. Within severely impacted areas, pine engraver beetle populations in central Arizona have killed up to 176 trees per acre, and nearly all tree size classes are affected (Parker, 1991). Roundheaded pine beetle outbreaks in New Mexico and Arizona have resulted in basal area reductions ranging from 25 to more than 50 percent (Negrón et al., 2000). Western pine beetle-caused mortality typically has been limited to small pockets of ponderosa pine within the recent history of Arizona, but the potential is there for extensive tree mortality (DeMars and Roettgering, 1982).

Although it is difficult to predict the extent and severity of beetle activity over the next few years within the Alpine area, we can expect additional levels of pine mortality as long as weather patterns continue to promote their expansion.

Prevention and Suppression alternatives for bark beetles

Management of bark beetle populations falls under two categories: direct action against the beetles themselves (suppression) or indirect action that addresses the general stand conditions (prevention). Direct action deals with the symptoms, too many beetles in one place at one time, and is aimed at directly reducing the number of beetles present. Indirect action focuses on the

cause of the problem, which relates to optimal stand conditions for beetle buildup and outbreak. The only effective long-range strategy to minimize beetle-caused mortality is controlling stand conditions through silvicultural means over entire landscapes and constant monitoring for areas of beetle buildup. The following are management alternatives available for consideration:

No action. Accept bark beetle-caused tree mortality and the impacts associated with it. The extent of the damage to the stands in this area and surrounding areas is difficult to estimate, but there will be changes in the forest caused by beetles. If stand and weather conditions remain optimal for beetle outbreaks, the impacts can be expected to be similar to those described in the “**effects of bark beetle infestations**” section.

Where to use: Use where other alternatives are not desired, cannot be used, or are not feasible.

Advantages: There is no mechanical site disturbance. There will be an increase in the amount of light getting to the forest floor, so that understory species and regeneration may be enhanced. Habitat for some wildlife species may be enhanced by decreasing crown closure and creation of standing dead trees.

Disadvantages: This alternative allows beetle populations to increase and spread to other trees and surrounding areas. Fire hazards can also increase with greater levels of dead material, including dry needles. Visual and recreation values can be negatively affected. The loss of overstory tree cover can have a negative effect for some wildlife species. Regeneration can be impeded as dead trees fall and cover or shade the forest floor. Watershed impacts are possible on steeper slopes due to the decrease in tree canopy interception and root activity.

Silvicultural treatments. These are forest management actions that increase tree vigor and reduce stand susceptibility to beetle attack through reducing basal area or controlling other stand conditions. They are preventive treatments that should be completed prior to stands experiencing beetle outbreaks. Stand hazard rating for *Dendroctonus* bark beetles of ponderosa pine involves measures of tree size, stand or group density (basal area), and the percent of host trees within the stand. In general, ponderosa pine stands that have an average DBH greater than 12 inches and a basal greater than 120 ft²/acre are considered at high risk to bark beetle attack (Schmid and Mata, 1992; Chojnacky, et al., 2000; Negrón, et al., 2000). In the White Mountains, stands that have less than 80 square feet of basal area per acre are at the lowest risk. No stand hazard rating models have been developed for pine engraver beetles species attacking ponderosa pine, primarily because beetle populations are driven by drought and factors leading to large amounts of slash. It is important to keep in mind that while thinning your trees is an excellent long-term preventive measure, thinning alone may not be enough to protect trees from bark beetles. In order for the leave trees to benefit from thinning, they need water before beetles start an attack. All the fresh cut “slash” (cut tree trunks, limbs and trimming debris) must be treated properly to keep beetles from breeding in it and moving into adjacent residual green trees.

Where to use: This is a preventive strategy and should be used regularly when planning tree removal and urban interface treatments. It is not a tool in stands currently experiencing a beetle outbreak.

Advantages: Controlling stand conditions can reduce overall stand susceptibility to beetle infestation. It does not guarantee that beetle-caused mortality will be eliminated; it creates conditions that are less likely to experience a beetle outbreak. It maximizes the economic return from tree removal, as cutting is done prior to mortality taking place. Although the forest will experience mortality through time, treating stands through silvicultural prescriptions allows the decisions on what the forest will look like in the future through the types of treatments implemented. If not, the beetles will decide what the forest will look like in the future through their actions, and this may be considerably different than management goals, or not within limits of change acceptable to the public.

Disadvantages: This action is not suitable for areas where tree removal or treatment of slash is not feasible. There are site disturbances associated with treatments or tree removal while the cutting is being done.

Sanitation/salvage removal. Sanitation removal involves removing currently infested pines prior to the beetle maturation and emergence. It requires the removal of green trees that have live brood in them. Trees removed are treated; either moved to at least one mile from the nearest live host type or processed at the mill, prior to beetle emergence. Salvage removal involves the taking away of beetle-killed trees that do not have live beetles in them. These trees have already changed color; all their needles are either red or gone.

Where to use: Stands susceptible to bark beetles that are currently under attack where it is desirable to reduce beetle populations and recover resource value. Also appropriate where beetle populations threaten currently uninfested nearby stands and adjacent private lands.

Advantages: Bark beetle populations can be reduced in localized areas and in individual stands by removing most of the currently infested trees. This can provide some protection to surrounding uninfested trees and stands by removing a large source of attacking beetles. Resource values are recovered that would otherwise be lost or degraded. Fuel loading and fire hazard can be reduced by removal of much of the dead needles and timber. Regeneration can be enhanced through overstory removal and site disturbance. Potential hazard trees are also removed from the site.

Disadvantages: This alternative has a short implementation time. Areas must be marked and cut prior to beetle flight, i.e., before the beginning of April or within 4 weeks of the initial attack. Sanitation will not be effective on a large scale. It is only effective at suppressing beetles at the stand level and so will not work on a landscape level. Site disturbance that accompanies tree removal occurs.

Infested tree treatment. Cut and individually treat infested trees prior to beetle emergence. The action should kill most or all of the beetles within the cut trees. Examples of treatments include: cut and burn on site, cut and bury at least 6 inches deep on site, cut and chip, or cut and debark. When burning infested trees or slash, the material does not need to be entirely consumed; only the outer bark and cambium needs to be charred significantly enough to kill the

brood. The use of a terra torch has been proven effective at treating infested green slash piles within the Alpine area.

Where to use: This is most appropriate for treating small spots in areas where high value resources are nearby.

Advantages: Small spot beetle populations can be reduced or eliminated from the treated area. This can provide some relief to surrounding uninfested stands and trees. The site disturbance is less than in conventional tree removal operations. Regeneration can be enhanced through the removal of overstory trees. Fire hazard and hazard trees can be reduced.

Disadvantages: The implementation time for this alternative is short. Treatments must be done after new infested trees are located and prior to beetle flight. This treatment only reduces beetle pressure in a small area; it is not effective on a landscape scale. This treatment does nothing to address stand conditions that led to beetle buildup in the first place.

Protection of high value trees. Valuable trees in recreation sites or near homes may be sprayed with carbaryl (Sevin) to prevent successful attack (Parker, 1991). Both the trunk and large branches (>4" diameter) should be sprayed. Because pine engraver beetles generally initiate attacks near the top of the bole, it is important that the spray reach this area. Attacking beetles die as they attempt to chew through the bark. Preventive sprays are not recommended for trees already attacked. Large-diameter green slash can potentially be protected using preventive sprays. Systemic injections of insecticides do not work either as a preventive or a direct control of bark beetles on pine (Haverty et al., 1996).

Where to use: On trees around residences, in campgrounds, or other high value areas. Trees must be of significantly high value and be under heavy beetle pressure to justify treatment costs.

Advantages: This action can be effective at protecting individual trees from becoming infested if applied properly.

Disadvantages: Insecticide application does not effectively reduce beetle populations or address the cause of the outbreak. It does not guarantee protection; application must be thorough for it to be effective. Many people have concerns regarding environmental contamination when using pesticides. It is extremely expensive on a large scale and, therefore, is only appropriate for high-value trees within a small area, such as in campgrounds and other administrative sites. Analysis of environmental effects is more involved before use on Federal lands is permitted, and application by a licensed pesticide applicator is required.

Use of bark beetle pheromones. A relatively new approach to managing populations of bark beetles includes the use of semiochemicals (e.g., pheromones produced by the beetles for aggregation or anti-aggregation behavior). One method involves mass trapping an area with funnel traps baited with a pine engraver beetle lure. A spillover effect (i.e., trees adjacent to the baited trees are also attacked) is commonly experienced when using this technique. The amount of spillover depends on the local population level of beetles. If spillover occurs, the infested

trees should be removed and treated as stated above. At this time, anti-aggregation pheromones for most pine engravers are not known.

Where to use: Funnel traps with pine engraver beetle lures can be used for monitoring beetle populations. In limited situations they also can be used in a trap out approach. In this case, 5-6 funnel traps per acre are placed in clusters or around the perimeter of an area to be treated. Use of pheromones is most effective in areas with a limited, but increasing beetle population. Funnel traps cost approximately \$40 per trap plus \$18 for a season's worth of pheromone lures per trap; total approximate cost per trap would be \$58 and approximately \$300 per acre.

Advantages: There is no site disturbance. Localized populations of beetles are reduced and may prevent further expansion of beetles within an area.

Disadvantages: This treatment only reduces beetle pressure in a small area; it is not effective on a landscape scale. This treatment does nothing to address stand conditions that led to beetle buildup in the first place.

Natural enemies and cold temperature effects. Other forms of control of bark beetle, such as natural enemies or environmentally related factors, are not predictable. Generally, when beetle populations reach outbreak proportions, natural enemies, such as birds and predaceous or parasitic insects, are not numerous enough to have a noticeable effect on the outbreak. Natural enemies are more important in limiting some bark beetle populations that are in the endemic phase (Bellows, et al., 1998). Past attempts at mass rearing insect predators (i.e., clerid beetles) of bark beetles have been met with several problems. Logistical problems arise through the fact that the immature predators must each be reared in individual containers, because often there is density-related mortality and because they can be cannibalistic. Therefore, costs of rearing these predators are prohibitive. Development of an adequate artificial diet has also been problematic. Furthermore, because it is very difficult to predict accurately when and where bark beetle outbreaks will occur, our ability to have enough natural enemies on hand to deploy is minimized. Finally, if natural enemy populations are augmented through releases, their inherent dispersal behavior results in many if not most of them leaving the area to be controlled.

Similarly, environmental factors cannot be counted on for lessening the outbreak. For example, temperatures of -10°F can kill beetles in October, but temperatures of -25° are needed by February (Schmid, et al., 1993). These temperatures need to be reached under the bark, in the phloem, as opposed to air temperatures. Beetles survive low temperatures by removing water from within their cells and replacing it with glycoproteins, which act as a type of anti-freeze (Bentz and Mullins, 1999). This is a process known as cold hardening. Beetles have supercooling points, the temperature at which ice crystals start to form in body tissues, as low as -32° F in January (Bentz and Mullins, 1999). Phloem temperatures become equal to air temperatures only when they persist for 24 hours or more (Schmid, et al., 1993). Generally, phloem temperatures are found to be 5 to 10°F warmer than air temperature.

Recommendations

Because the current beetle infestation is occurring on the landscape scale and is largely a result of the ongoing drought, it is essentially impossible to control the beetle population as a whole through management actions. Therefore, an integrated pest management approach should be limited to the most critical high-value areas that have adequate accessibility. As a consequence, the “no action” alternative may be appropriate for areas already severely impacted by bark beetles and areas distant from the wildland urban interface (WUI) and other critical locations.

Sanitation removal or treatment of infested trees is appropriate within the WUI and other high-value areas.

If a thinning project is undertaken, careful management of the slash is required while populations are high. Burning, chipping, or burying green material will help to reduce the potential for additional population increase of beetles. Thinning will be most effective in areas that are not currently experiencing high levels of beetle activity. For example, the area west of town that is slated for fuels reduction work next year would be a good choice. Residual trees in areas that are currently experiencing high levels of pine mortality may not have the opportunity to respond to thinning treatments. We observed this northeast of town, where many of the residual trees were attacked by beetles following the thinning treatment last winter through this spring, despite immediate removal of slash. In this case, the trees were not able to respond because there was essentially no water available to them after November 2001.

Although no experimental studies have been conducted to examine the relationship between chipping and bark beetle attraction, we do know that bark beetles are attracted to host tree compounds such as terpenes. Fresh cut trees and chips release high quantities of terpene volatiles that can attract bark beetles. To minimize the potential of chips attracting bark beetles, chips should be spread out as much as possible in open areas rather than in shaded areas. Try to prevent piling the chips at the bases of pine trees. If the chips are spread out in a thin layer and out in the sun, they will dry quickly and, therefore, stop emitting terpene volatiles. Chipping in the fall probably has less risk than chipping at other times of the year.

Monica informed me that green slash generated from thinning projects within the WUI would be moved to an area near Nutrioso. Most of this area is dominated by open grasslands and pinyon-juniper stands; therefore, the slash will be piled approximately $\frac{1}{2}$ mile from the nearest ponderosa pine. Aerial surveys in this area detected relatively low levels of bark beetle activity in the ponderosa pine stands. As a whole, the risk of pine engraver beetles finding the slash and successfully producing brood is reduced because of the location. However, to further minimize the risk of beetle populations increasing within this area, pile height should be restricted and the largest diameter material laid on the outside of piles. This will promote faster drying of the slash. Possibly orienting log/pole decks with the long axis pointed north-south could help maximize daily sun exposure of bark. Periodic monitoring of the slash should be conducted to see if beetles are using the material. Other alternatives for treating the slash include peeling or scorching the bark of the largest diameter material, or burning slash on-site in an air curtain destructor.

Based on the current stand conditions and setting, trees within several of the campgrounds seem to be highly susceptible to beetle attack. Therefore, removal of infested trees is recommended

and may also provide some protection to surrounding trees. However, because these insects are very common, removal of infested trees is not a guarantee of protection. This approach is generally only recommended in combination with the long-term preventive approach. It is recommended that the infested trees be removed yet this winter before the brood completes their development and adult beetles emerge. If trees are cut, they must either be removed from the site or, if left, the bark should be stripped off to kill the developing beetle brood. To provide short-term protection of the residual high-value green trees, spraying of trees around campsites should be considered for the duration of the outbreak. Spraying will need to occur in early spring, prior to beetle flight.

Another concern associated with generating slash and felling infested trees is the collection of this material for firewood. Homeowners and other people should avoid collecting green firewood or recently generated slash infested with pine engraver beetles. Beetles can emerge from the firewood and attack neighboring trees. Firewood collectors should be advised to split and or peel the firewood before stacking in their yard if gathering wood from free-use piles. Keeping the burn pit provided for citizen tree disposal burned on a biweekly basis is encouraged.

Forest Health Protection Funds for FY2003 may be available to deal with bark beetle activity within the Alpine area. Requests for these funds should be in no later than October 1, 2002. If you have any questions regarding my assessment of current bark beetle activities within the project area, its potential effect on residual standing trees, or my recommendations, please let me know. I can be reached at (928) 556-2074.

/s/ Joel D. Mcmillin
JOEL D. McMILLIN
Entomologist, Forest Health, Arizona Zone

cc: Monica Boehning, John Anhold, Leonard Lucero, Debra Allen-Reid, Douglas L Parker,
Douglas Beal

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